The 2017 Winter Weather Experiment: Results and Verification Methods

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Experimental Overview

- The 2017 Winter Weather Experiment (WWE) took place for four weeks: January 17 – February 17, 2017.

- 28 participants with diverse backgrounds:
  - Various WFOs, EMC, MDL, STI, AFS, ESRL, DTC, SPC, 3 different universities.

- Experiment activities:
  - Day 1 (18-12 UTC) Probabilistic Hourly Snowfall Rate forecast.
  - Day 2 (12-12 UTC) Deterministic Snow/Ice CONUS forecast.
  - Day 2 (12-12 UTC) Winter Weather Watches/Alerts.
  - Subjective evaluation of model guidance and forecasts.

VERIFICATION RESOURCES

WPC Stage IV/RAP Analysis

- Components:
  - Hourly Stage IV QPE.
  - Hourly 13 km RAP initialization fields.
- Uses WPC algorithm to determine PTYPE.
  - Checks for freezing temperatures at 925, 850, and 700 hPA.
  - 2 m temperatures used to differentiate rain/freezing rain.
- 10:1 SLR applied for areas identified as snow.
- 2:1 ratio applied for sleet.
- Used to verify:
  - Hourly probabilistic snowfall rate forecast.
  - Freezing rain.
  - WPC joint probabilities.
  - WPC Winter Weather Alerts.
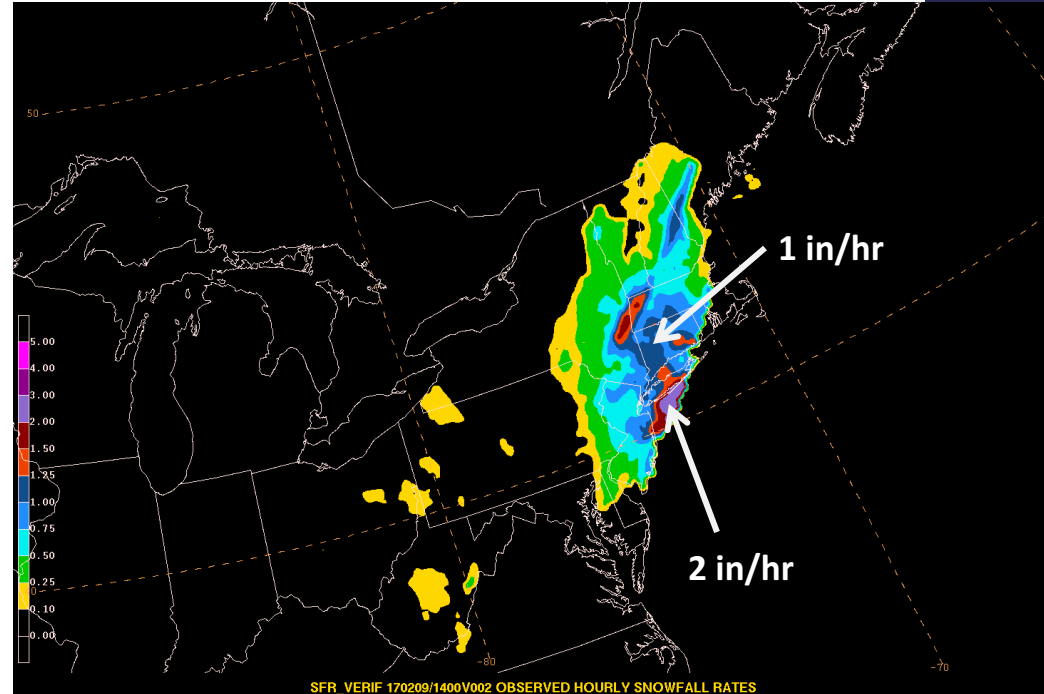
Stage IV/RAP Analysis hourly snow verification valid at 1400Z 02/09/17.
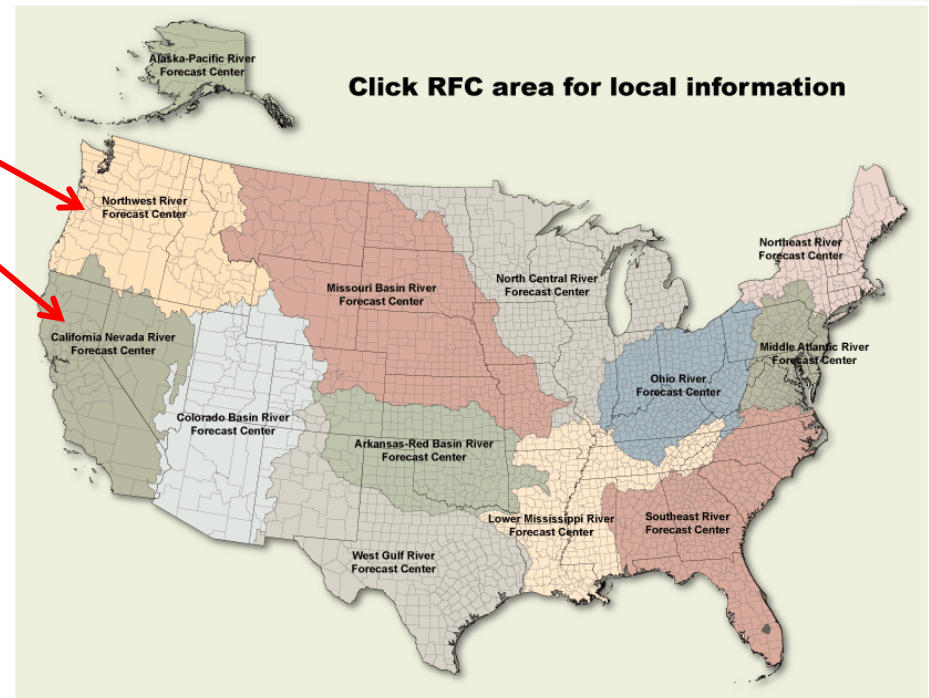
WPC Stage IV/RAP Analysis

- Problems encountered with the analysis:
  1. No hourly Stage IV QPE data received from the Northwest River Forecast Center (RFC) or the California-Nevada RFC.
     - Leads to no data in those regions.
     - These areas experienced extensive winter weather during this year's experiment and hourly rate forecasts were created but were unable to be verified.
  2. The 10:1 Snow-to-Liquid Ratio (SLR).
     - Participants questioned whether a 10:1 SLR was the best way to determine snowfall amounts, especially for a few colder events in New England and lake-effect events.

Click RFC area for local information

Alaska-Pacific River Forecast Center
Northwest River Forecast Center
California Nevada River Forecast Center
Colorado Basin River Forecast Center
Missouri Basin River Forecast Center
North Central River Forecast Center
Arkansas-Red Basin River Forecast Center
West Gulf River Forecast Center
Lower Mississippi River Forecast Center
Ohio River Forecast Center
Southeast River Forecast Center
Northeast River Forecast Center
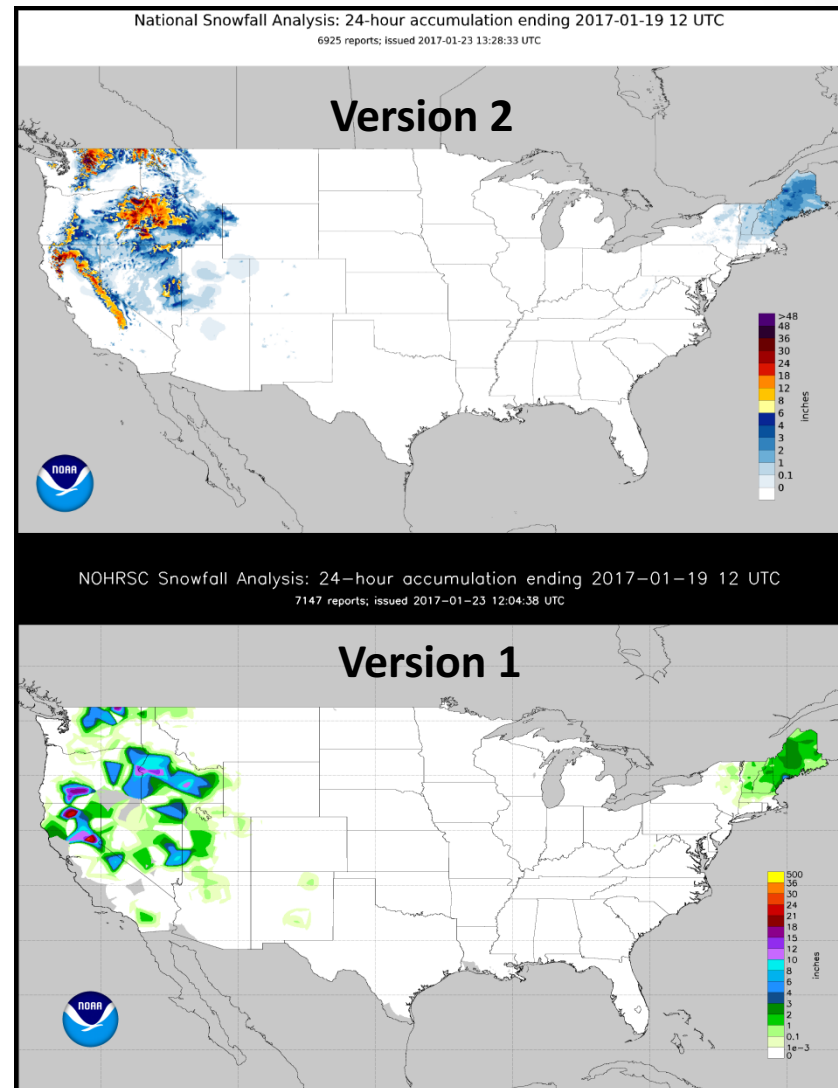Middle Atlantic River Forecast Center

NOHRSC National Snowfall Analysis Version 1 and 2

- Version 1:
  - Used two-day quality-controlled 24 hour 1200 UTC NOHRSC snowfall analysis.
  - Data sources include:
    - All possible observation networks (e.g. COOP and CoCoRaHS).
    - A spatial interpolation of these observations is performed via a fixed, Barnes 2-pass, method with fixed interpolation parameters.

- Version 2:
  - Began running early January 2017 in pre-experiment/non-operational mode.
  - Some changes include:
    - Improvements to automatic quality control.
    - Inclusion of bias-corrected first-guess field based on aggregated HRRR water equivalent snow depth.
    - Improved SLR.

NOHRSC National Snowfall Analysis Version 1 and 2

- Version 2 showed tremendous promise over the Western United States.

- Was used during the experiment for snowfall verification for cases in the West.

National Snowfall Analysis: 24-hour accumulation ending 2017-01-19 12 UTC
6925 reports; issued 2017-01-23 13:28:33 UTC

Version 2

NOHRSC Snowfall Analysis: 24−hour accumulation ending 2017−01−19 12 UTC
7147 reports; issued 2017−01−23 12:04:38 UTC

Version 1

Satellite-based Snowfall Rate (SFR) Algorithm

- Evaluated in the experiment as a viable verification resource for snowfall rate forecasts.

- The SFR output was compared against the Stage IV/RAP Analysis:
  - Where the Stage IV/RAP Analysis had data.
  - When a satellite pass captured areas of snowfall.

- Detects snowfall and determines intensity using 5 polar orbiting satellites and NWP data as a last screening step.

- Upper limit of 2 inches per hour from the SFR.

- The SFR does not provide reliable readings when temperatures are below 7°F, thus those areas are masked out in the display.

Satellite-based Snowfall Rate Algorithm

- Average subjective score from participants 5.6/10.
- Tends to miss lake effect events because snow is too shallow for the microwave sensor to sense.
- Areas along edge were sometimes distorted due to limb effect from imager sweep.
- Overall, participants agreed it would be useful to have as real-time observations in areas of poor radar coverage and lack of ground observations.
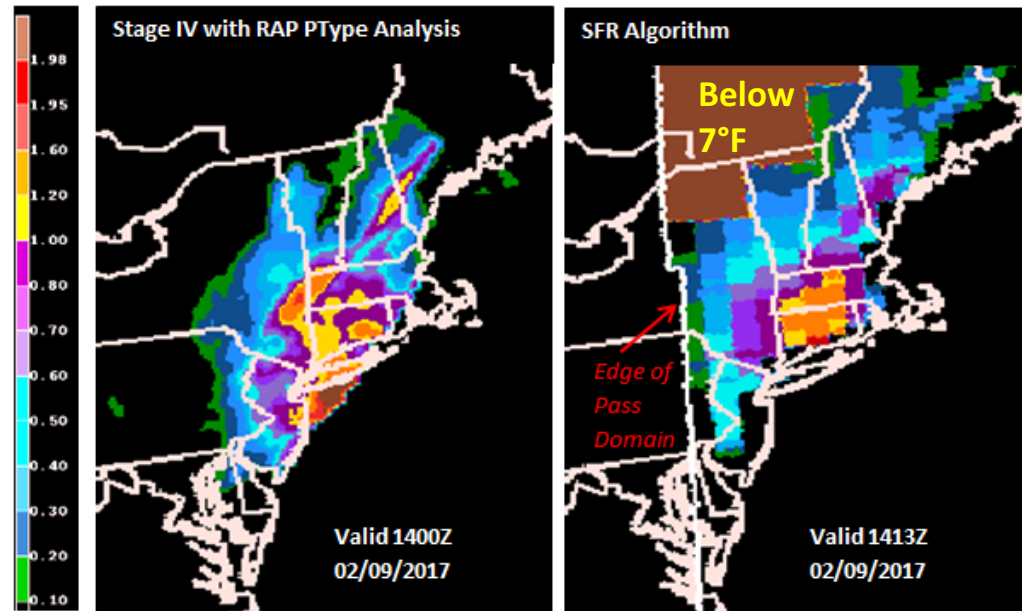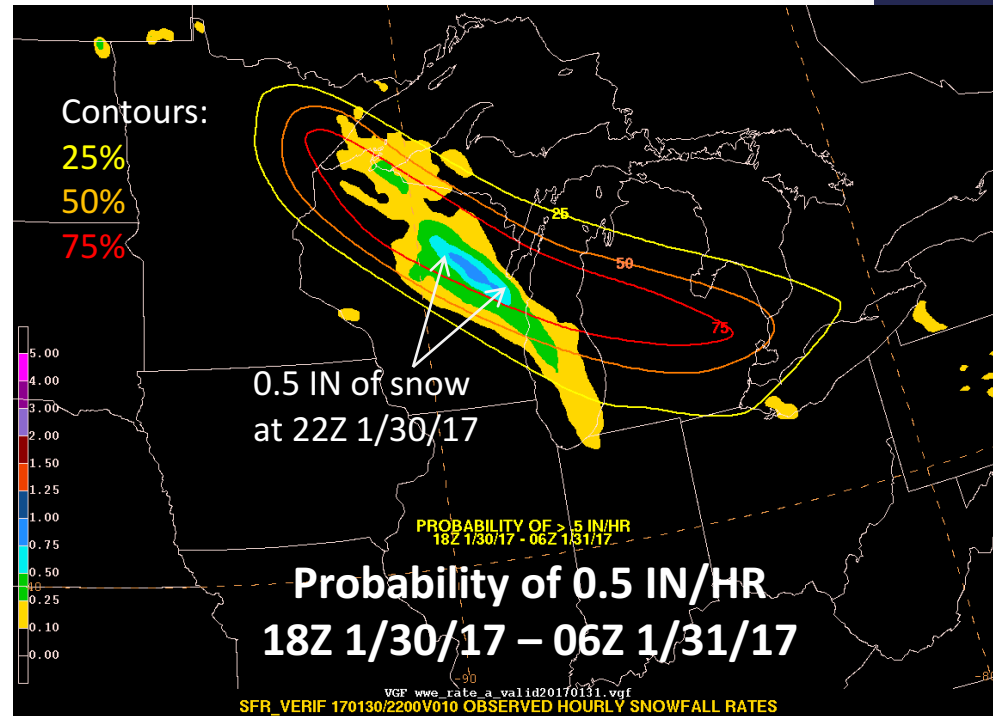

Stage IV/RAP Analysis (left) and SFR Algorithm (right) valid at 14Z 02/09/17.

WWE FORECASTS

Day 1 Probabilistic Hourly Snowfall Rate Forecast (18-12 UTC)

- Each day participants chose:
  - Threshold 0.5/1/2 inches of snow.
  - A limited geographic area to forecast within.
  - Probability contours of 25/50/75%.
 - A time interval ranging from 3-18 hours.

Contours:
25%
50%
75%

0.5 IN of snow at 22Z 1/30/17

PROBABILITY OF > .5 IN/HR
18Z 1/30/17 - 06Z 1/31/17

Probability of 0.5 IN/HR 18Z 1/30/17 – 06Z 1/31/17

VGF wwe_rate_a_valid20170131.vgf
SFR_VERIF 170130/2200V010 OBSERVED HOURLY SNOWFALL RATES

Example probabilistic hourly snowfall rate forecast overlaid with verification.

Day 1 Probabilistic Hourly Snowfall Rate Forecast (18-12 UTC)

- Subjective scores from the participants:
  - Mean = 6.5
  - Median = 5.0
  - St. Dev = 1.7
- Forecasts were challenging to verify out West for reasons mentioned earlier (slide 5).
- Participants most common critiques:
  - Forecast too confident based on verification.
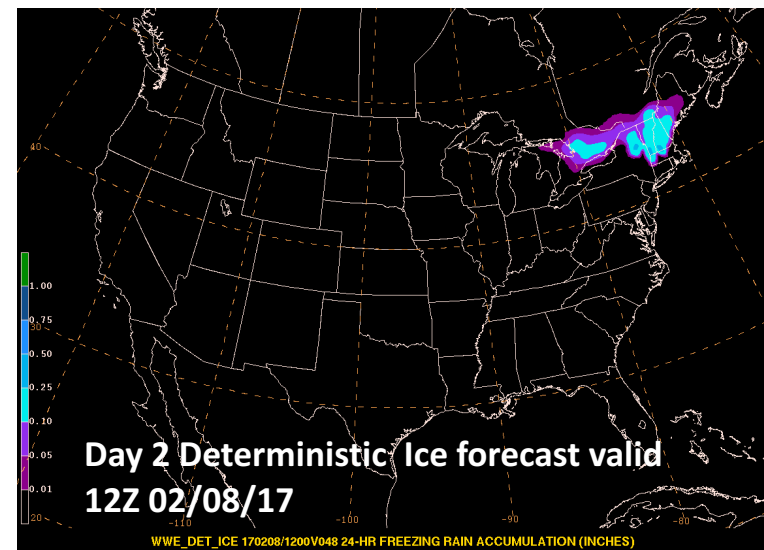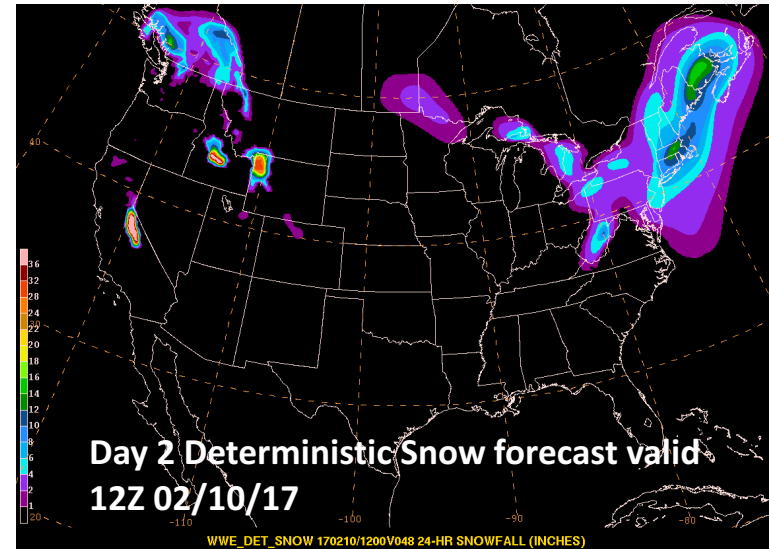 - Probabilities too high for chosen threshold.
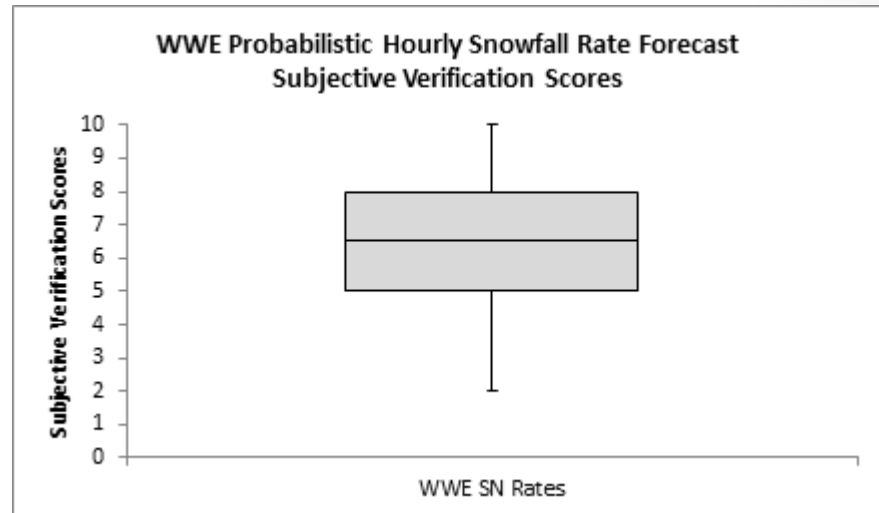
Box plot of probabilistic hourly snowfall rate subjective results.
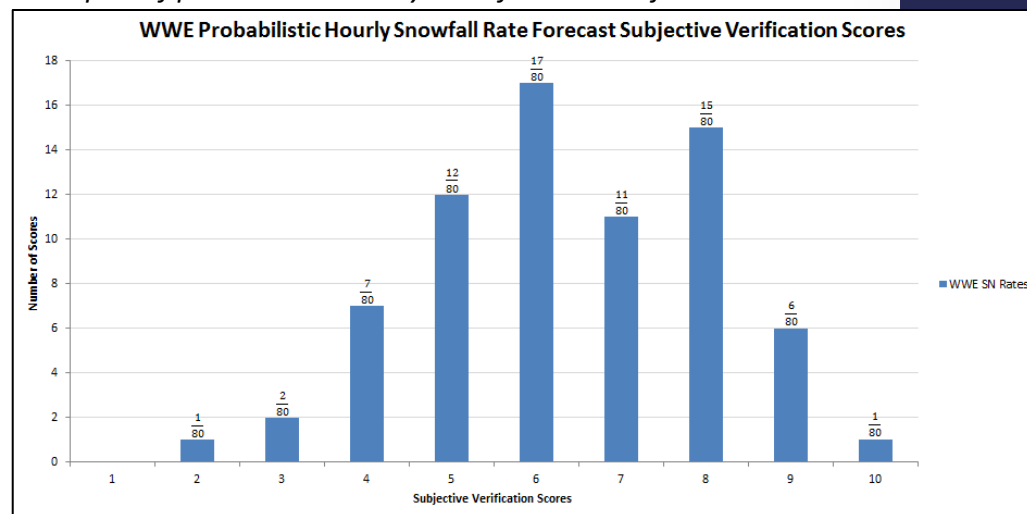
*Hourly snowfall rate subjective results score distribution.*

Day 2 Deterministic 24 HR Snow and Ice Forecast

- Created Day 2 (12-12 UTC) deterministic forecasts over the CONUS:
  - Snow → 1, 2, 4, 8, 12, 20 inches and higher
 - Ice → .01, .10, .25, >=0.5 inch

Day 2 Deterministic Snow forecast valid 12Z 02/10/17

WWE_DET_SNOW 170210/1200V048 24-HR SNOWFALL (INCHES)

Day 2 Deterministic Ice forecast valid 12Z 02/08/17

WWE_DET_ICE 170208/1200V048 24-HR FREEZING RAIN ACCUMULATION (INCHES)

Day 2 Deterministic 24 HR Snow and Ice Forecast

- Day 2 Snow Forecast:
  - Mean → 5.9
  - Median → 5.9
  - St. Dev → 1.3
- Day 2 Ice Forecast:
  - Mean → 6.0
  - Median → 6.0
  - St. Dev → 2
- Very difficult to verify freezing rain.
- Common criticism of snowfall forecasts was that amounts were almost always underdone.
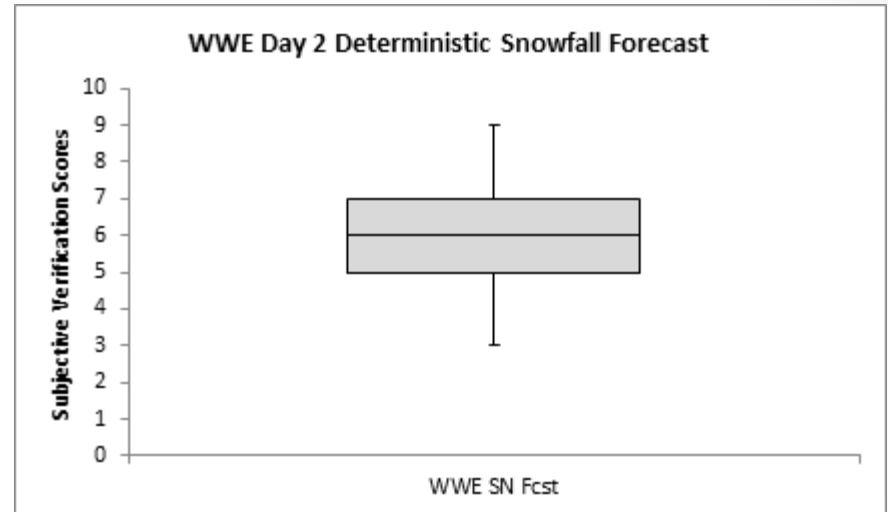

Box plot of Day 2 deterministic snowfall forecast subjective results.
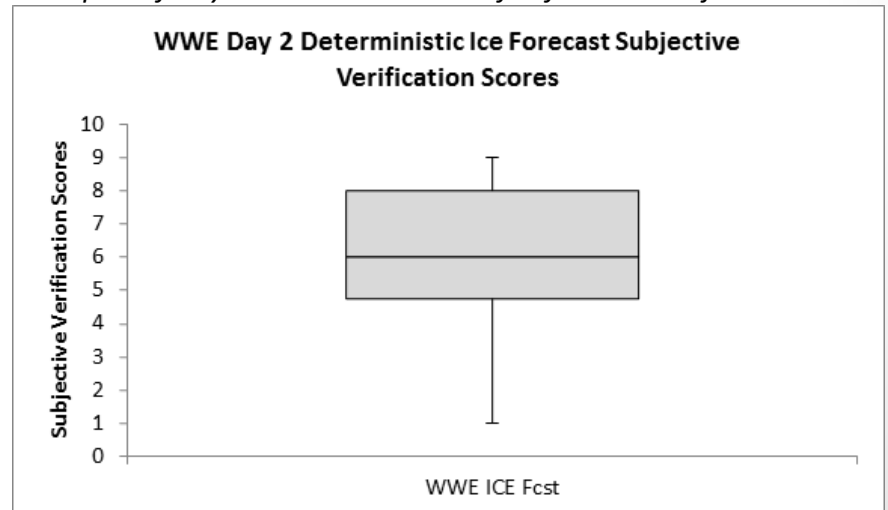
Box plot of Day 2 deterministic ice forecast subjective results.

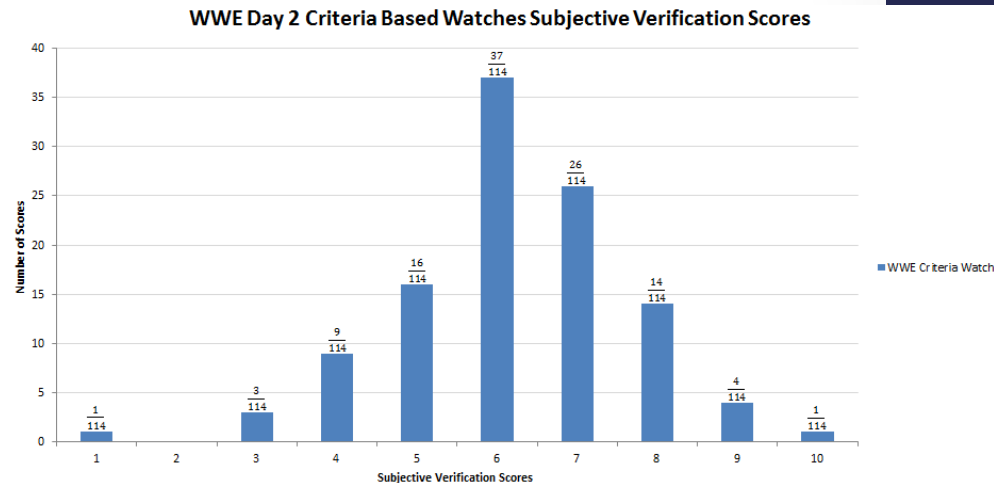# Day 2 Winter Storm Watches/Alerts

- First time issuing experimental Winter Storm Watches from National Center.

- Watches (24 hours) were based on Day 2 deterministic forecast, WFO watch/warning criteria, and WPC Watch Collaborator.

- Alerts (6-24 hours) based on WPC developed joint probability tools and other guidance.

  - Tried to convey impacts not possible with traditional 24 hour watches.
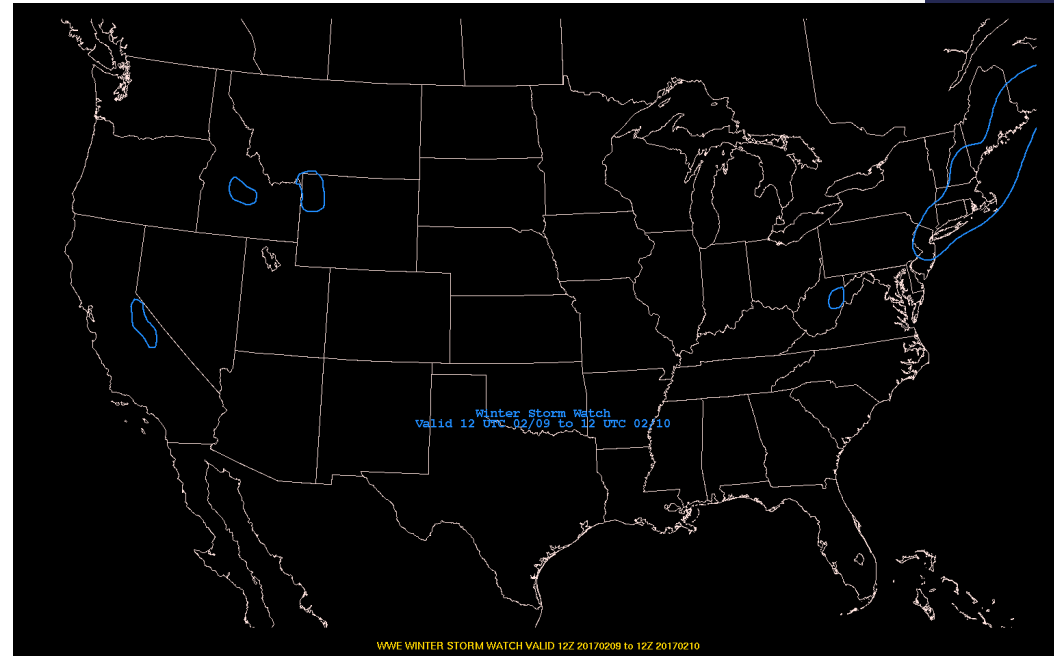
Example of criteria-based Winter Storm Watch issued on 02/08/17 valid at 12Z 02/10/17.

Day 2 Winter Storm Watches

- To verify criteria-based watches, NOHRSCv1/2 was compared to WFO warning criteria.

- The watches generally captured most events, however spatial extent of the watches was often too conservative or missed marginal events.

- Questions also arose as to how a National Center would handle small-scale areas, especially out west, and workload.


Criteria-based Winter Storm Watch subjective results score distribution.

Day 2 Winter Weather Alerts

- Relied heavily on Stage IV/RAP Analysis for sub-24 hour snowfall/ice, so western areas were difficult to verify.

- Generally, participants liked the added flexibility of issuing an alert for impactful events in a timeframe less than 24 hours.

- Alerts also had same issues as the watches where the spatial extent could have been larger.
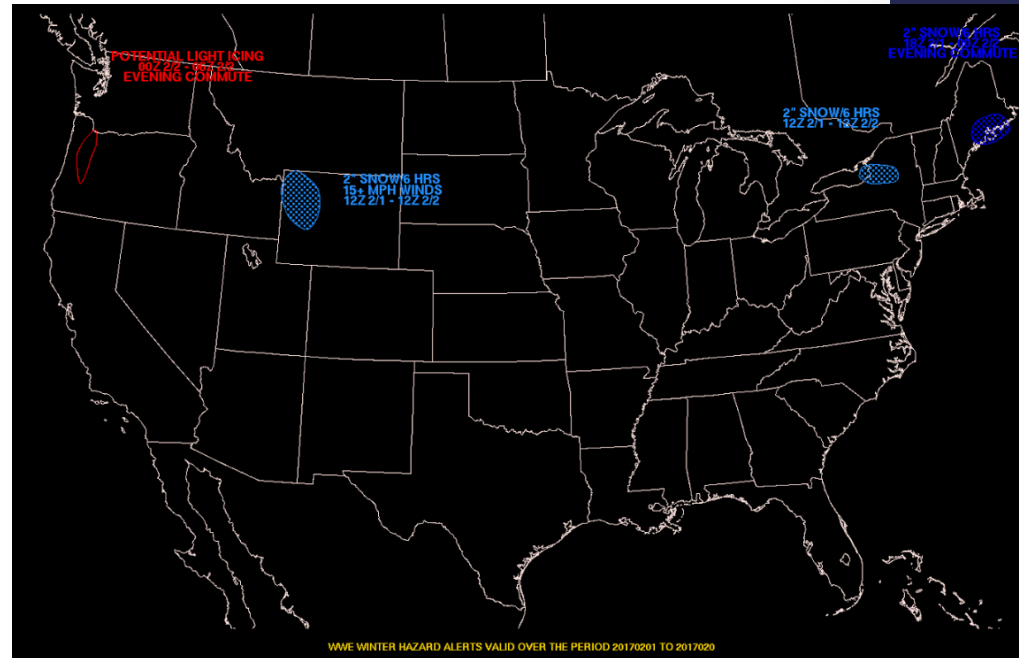
Example of Winter Weather Alert valid at 12Z 02/02/17.

Conclusions

- Hourly probabilistic snowfall rate forecast successful.
  - Second year testing.
  - Changed/improved model data this year.
  - Plan to make guidance available to forecasters.
- Day 2 deterministic snow forecasts were often underdone but forecasters added value in areas out west where modeled amounts were often low.
- Successful first test of issuing criteria-based Winter Storm Watches from a National Center.
  - Gathered good feedback on challenges that will need to be addressed moving forward.
- Winter Weather Alerts popular among participants due to the flexibility they provided, such as less than 24-hours in length and highlighting specific impacts.
  - Difficult to verify to see how effective the alerts actually were.

Observational Conclusions

- Verification:
  1. WPC Stage IV/RAP Analysis was the only option for sub-24 hour snowfall amounts.
     - Had issues in two western RFCs that do not provide hourly QPE.
     - 10:1 SLR questioned.
     - Need a better/more reliable way to verify less than 24 hour snowfall amounts.
  2. NOHRSCv1 extremely inadequate for verifying snowfall accumulations out west.
     - Version 2 showed tremendous promise, especially in the west, and has since transitioned to "prototype data" stage as of March 15, 2017.
  3. Freezing rain verification remains extremely difficult.
  4. The satellite SFR algorithm showed promise in the ability to provide snowfall rate information in areas of poor radar coverage.

# Day 1 Probabilistic Hourly Snowfall Rate Forecast (18-12 UTC) Featured Guidance

- HRRRv3/NAMv4 hourly snowfall accumulation

- NAMv4 max hourly snowfall rate

- HRRR-TLE hourly snowfall rate probability

- NCAR Ensemble hourly snowfall rate probability
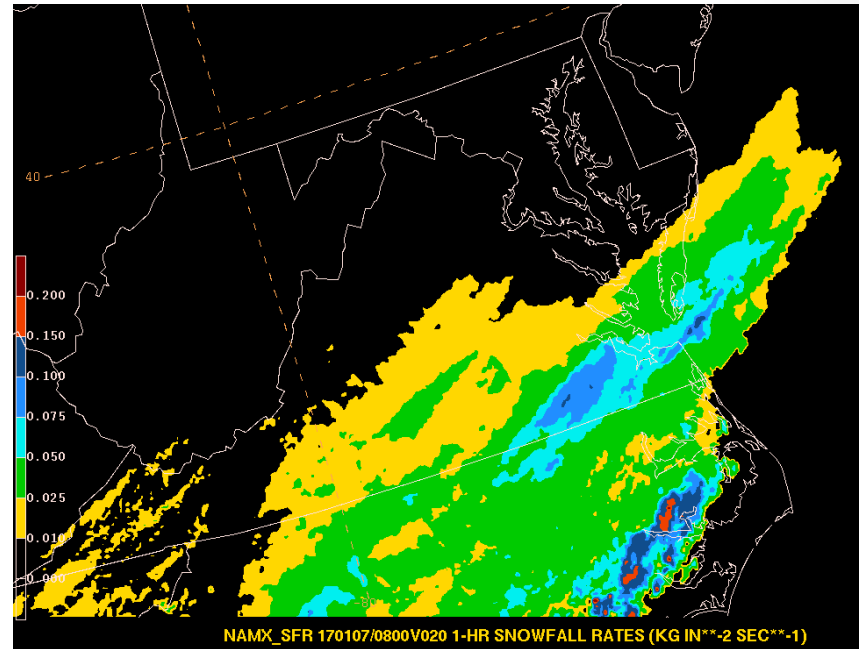
NAMv4 Max Hourly Snowfall Rate valid at 08Z 01/07/17.

# Day 2 Deterministic 24 HR Snow and Ice Forecast Featured Guidance

- WPC Experimental Implicit PWPF
- WPC Operational PWPF
- WPC Winter Weather 5km Ensemble
- WPC Implicit Blend
- NAMv4
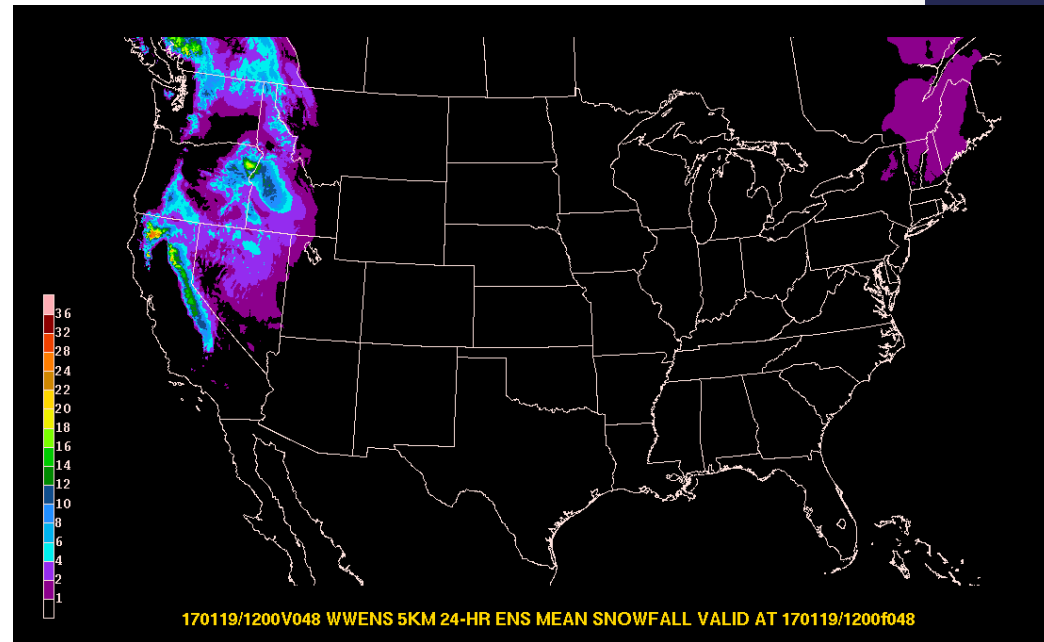
WPC Winter Weather 5 km Ensemble 24 hour Day 2 snowfall forecast valid at 01/19/17.

Day 2 Winter Storm Watches/Alerts Featured Guidance

- WPC Joint Probabilities

- WPC Watch Collaborator

- WPC Watch Collaborator Trend Tools

- Winter Storm Severity Index

JOINT_PROB 161118/1800V030 6-HOUR JOINT PROBABILITY OF SNOW > 2 INCHES WIND > 15 MPH
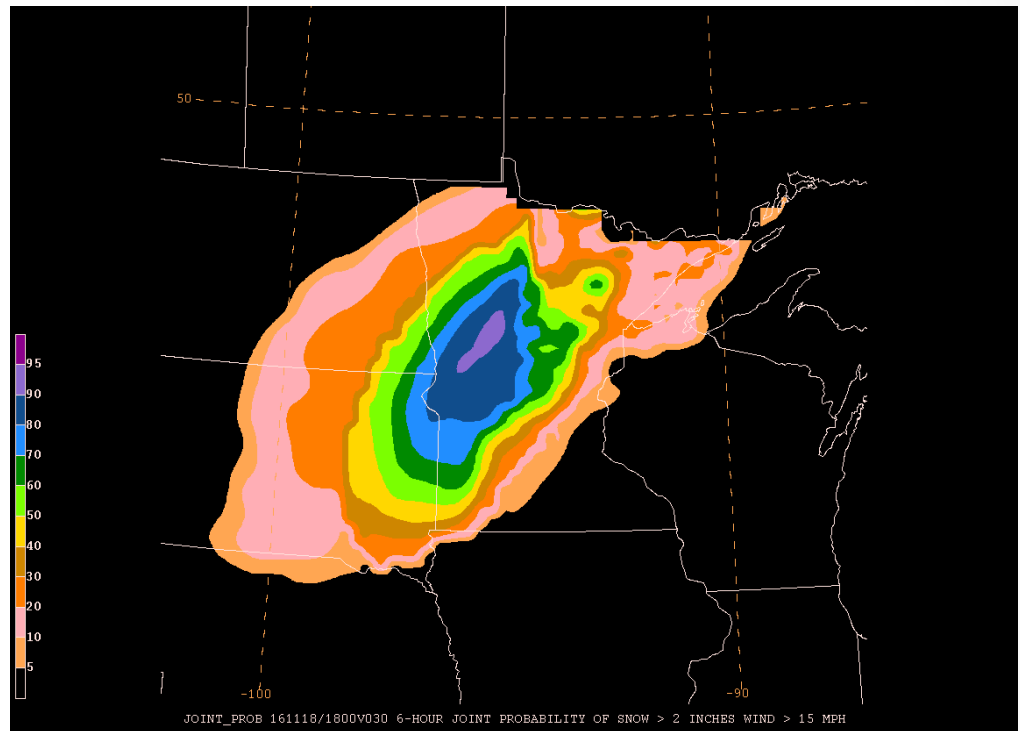
WPC Joint Probability of > 2 inches of snow and > 15 mph winds in a 6 hour period valid 18Z 11/18/16.